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# BRIEF COMMUNICATION

# Electric Shock Delivery System for Rhesus Monkeys: Its Effect on Escape Responding[1]

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JOHANSON, C. E. AND M. J. FRANCO. *Electric shock delivery system for rhesus monkeys: its effect on escape responding.* PHARMAC. BIOCHEM. BEHAV. 8(4) 505–508, 1978. – The present experiment evaluated a simple chronic electric shock delivery system for rhesus monkeys restrained by a harness and arm arrangement used in experiments involving intravenous drug delivery. Electric shock was delivered via two small electrodes surgically implanted in the lumbar muscle. During experimental sessions, responding on a fixed-ratio 10 schedule terminated the delivery of a train of 100 electric shock pulses and produced a 3 min timeout. A maximum of 19 trials were possible during each daily session. Overall rate of responding increased as electric shock intensity was increased from 0 to 4 mA and the characteristics of responding were similar to previous studies using other systems and species. The results demonstrate that electric shock delivered by the present system is a negative reinforcer. In addition, the system is easy to implant, causes little tissue damage, relatively long-lasting and can be used in experimental situations which involve responding maintained by intravenous drug delivery in rhesus monkeys.

Electric shock  Escape  Drug self-injection

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THERE have been relatively few studies of the effects of punishment on behavior maintained by intravenous drug delivery [4,5]. In part, this deficit has been a function of the complexities of adapting an electric shock delivery system to those already developed for maintaining animals with intravenous catheters.

In many laboratories studying drug reinforcement, rhesus monkeys prepared with chronic venous catheters are used. Although electric shock can be successfully delivered when monkeys are in a restraining chair, many studies of drug-maintained responding with rhesus monkeys use alternative arrangements that have advantages in long-term studies. One such arrangement, described in detail by Schuster and Johanson [7], involves restraint within an experimental cubicle by a harness and flexible hollow arm through which the catheter runs. The present report describes the evaluation of an electric shock delivery system designed to be compatible with this method. Before attempting to use this shock delivery system to study the effects of punishment on drug-maintained responding, its efficacy in a procedure not involving drugs was determined.

## METHOD

### *Animals*

Two adult rhesus monkeys, one female (3157) and one male (4028), weighing between 5 and 6.5 kg were used. Both animals had extensive experimental and drug histories with responding maintained by intravenous cocaine. The animals were surgically prepared with electric shock electrodes while under sodium pentobarbital (30 mg/kg, IV) or phencyclidine hydrochloride (0.5–1.0 mg/kg, IM) anesthesia. The electrodes were two, round gold-plated silver disks, 0.6 cm in diameter. A small incision was made with a scalpel in the area to the right of the spinal cord and the electrodes were implanted, 2–5 cm apart, within the lumbar muscle and secured by suture. A 28 gauge stranded silver-coated wire that was insulated with teflon was soldered to each electrode. The solder joint between the electrode and wire was covered with dental acrylic. Both wires were threaded subcutaneously from the incision and exited through a second incision in the back of the animal. Resistance values were measured daily 5 min prior to the

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session with an ohm meter. If the value was greater than 50 KΩ, it was assumed that the electrodes were no longer capable, for mechanical or chemical reasons, of delivering the specified level of electric shock current. If this occurred, a new pair of electrodes was implanted as before in the left lumbar muscle prior to any further experimental sessions.

Animals had continuous access to water and were given 20–30 Purina Monkey Chow biscuits and a sugar cube saturated with liquid vitamins daily.

### *Apparatus*

Each animal was housed in a wooden, front-opening, sound-attenuating chamber that was 68.6 cm wide, 76.2 cm high and 83.8 cm deep. A fan was located on the front door for ventilation. On the inside of the front door were two metal boxes (15.2 cm × 12.7 cm × 10.2 cm), 20 cm from the floor and 10 cm from the center, each containing a response lever (BRS/LVE, PRL 001/121–07, Beltsville, MD) and 4 stimulus lights, two covered with red Dialco lens caps and two covered with green Dialco lens caps. The lights were 6.4 cm above the lever and evenly spaced 3.8 cm apart. The entire ceiling of each chamber was made of Plexiglas and could be transilluminated by either white or red lights.

Each monkey wore a stainless steel harness that was attached to a spring arm 46 cm in length and 1.3 cm in diameter (E and H Engineering, Chicago, IL) which in turn was attached to the back wall of the cubicle (see [7] for details). This arrangement allowed the monkey relatively unrestricted movement and provided protection for the electrode wires which were threaded through the arm. Outside the cubicle, the electrode wires were connected to a constant current electric shock generator (BRS/LVE, SG–903, Beltsville, MD). Cables connected the cubicles to solid state programming and recording equipment (BRS/LVE, Beltsville, MD) located in an adjacent room.

### *Procedure*

Each experimental session lasted 1 hr and began with a 3 min timeout (TO) during which the red ceiling light was illuminated and responses had no programmed consequences. The rest of the session consisted of a series of trials. When a trial began, the white ceiling and red stimulus light over the right lever were illuminated. Simultaneously, electric shock pulses 300 msec in duration were delivered, one every 585 msec. The electric shocks continued until 100 pulses had been delivered (58.5 sec) or until the animal had made 10 responses on the right lever (FR 10 escape). Responses on the left lever had no programmed consequences. Following either the delivery of 100 electric shock pulses or the completion of the FR 10, there was a 3 min TO during which responses had no programmed consequences. After the TO, a new trial began as before. This sequence continued for 1 hr during which a maximum of 19 trials could be completed.

The number of trials each animal escaped by completing the FR 10 requirement as well as the total number of electric shocks delivered were recorded. The time in seconds from the onset of the first shock pulse to both the first response (latency) and the last response were recorded on elapsed time meters. The measures were used to calculate overall response rates and running response rates (rate of responding not counting initial latency).

Manipulations were made in the intensity of the electric shock (Table 1). In most cases, electric shock intensities were changed after three sessions of stable performance.

## RESULTS

Both animals reliably escaped the electric shock at intensities above 2 mA. A representative cumulative response record is shown in Fig. 1; responding was typical of ratio performance with an initial pause followed by a high rate of responding.

Table 1 indicates the number of trials during which each animal completed the FR 10 escape requirement (trials escaped) as well as the number of trials that were terminated after 100 electric shock pulses were delivered (trials not escaped) as a function of electric shock intensity. Few trials were escaped by Animal 3157 at 0 and 1 mA. At the higher intensities, every trial was escaped. The data were similar for Animal 4028 except at the intensity of 1 mA, approximately half the trials were escaped. Redeterminations of the effects of 0 and 2 mA yielded data similar to the original.

Figure 2 shows mean overall response rate and mean running response rate for both animals as a function of the intensity of the electric shock. For both 3157 and 4028, overall response rate generally increased as the electric shock intensity increased. Running response rate, which is the rate of responding from the first to the last response of the ratio, showed little systematic change as a function of intensity.

Both rates during the second determinations at 2 mA were higher for both animals compared to the original data and were similar to the rates for 4 mA. As shown in Table 1, the latency from the onset of electric shock pulses to the first response of the ratio decreased as intensity increased.

For Animal 3157, resistance values varied between 17 K and 34 KΩ and for Animal 4028 between 12 K and 21 KΩ. For both animals, these fluctuations were unsystematic and unrelated to any changes in responding. As Table 1 indicates a second pair of electrodes was required for both animals during the course of the experiment. The original pair for Animal 3157 was presumed non-functional when its resistance value exceeded 50 KΩ and escape responding decreased. For Animal 4028, an infection developed at the site of the incision and the electrodes were rejected. This infection also resulted in the loss of the catheter. In other experiments, animals have had electrodes implanted for over 9 months [5]. Electrodes have become nonfunctional, as evidenced by sudden increases in resistance, as a result of infection, discontinuity due to breaks at the solder joint or in the wire itself and displacement of the electrodes from the muscle. There was no evidence at any time that the actual delivery of electric shock resulted in tissue damage. The duration of a functional pair of electrodes is of the same magnitude as that of the intravenous catheter.

## DISCUSSION

A negative reinforcer is a stimulus that will maintain responding which results in its termination (escape) or postponement (avoidance) [8]. In the present study, responding which terminated electric shock delivered via electrodes implanted in the lumbar muscles of rhesus monkeys was maintained under a fixed-ratio 10 schedule

TABLE 1

SUMMARY OF EXPERIMENTAL CONDITIONS IN ORDER OF PRESENTATION FOR ANIMALS 3157 AND 4028

| Order | Int (mA) | Number of Sessions | Latency (sec) | | Number of Trials Escaped | | Number of Trials Not Escaped | |
|---|---|---|---|---|---|---|---|---|
| | | | X̄ | Range | X̄ | Range | X̄ | Range |
| Animal 3157 | | | | | | | | |
| 1 | 2 | 4 | 2.0 | 1.7– 2.2 | 19 | – | 0 | – |
| 2 | 0 | 7 | 8.2 | 4.2–10.5 | 3.7 | 2–5 | 11.3 | 10–13 |
| 3 | 1 | 7 | 35.1 | 12.1–58.1 | 1.3 | 0–3 | 13 | 12–14 |
| 4 | 4 | 8 | 1.2 | 1.1– 1.3 | 19 | – | 0 | – |
| 5 | 2* | 6 | 1.1 | 1 – 1.2 | 19 | – | 0 | – |
| 6 | 0 | 3 | 18.5 | 16.9–21.3 | 3 | 2–4 | 12 | 11–13 |
| Animal 4028 | | | | | | | | |
| 1 | 2 | 3 | 1.3 | 1 – 1.5 | 18 | 17–19 | 0 | 0–1 |
| 2 | 0 | 6 | – | – | 0 | – | 14.3 | – |
| 3 | 1* | 12 | 8.5 | 6.7–10.4 | 9 | 7–12 | 7.3 | 5–9 |
| 4 | 4 | 8 | 1.2 | 0.8– 1.3 | 19 | – | 0 | – |
| 5 | 2 | 6 | 1.9 | 1.6– 2.3 | 19 | – | 0 | – |
| 6 | 0 | 14 | 22.2 | 20.9–23.5 | 1.7 | 0–3 | 13 | 12–14 |

*New electrodes implanted prior to condition.

(FR 10 escape) at intensities above 1 mA. Number of escapes and overall response rate increased and latency decreased as a function of electric shock intensity. Running response rate, however, was generally unaffected by changes in intensity. At all electric shock intensities, ratio-like performance was observed [3]. These results, showing that electric shock delivered via implanted electrodes can function as a negative reinforcer are generally similar to the results of other studies involving different delivery systems and animal species [1, 2, 6, 9]. In addition, Dinsmoor and Winograd [2] found that rate of responding was unaffected when electric shock was presented in a descending series. In the present study, although rate of escape responding increased as intensity

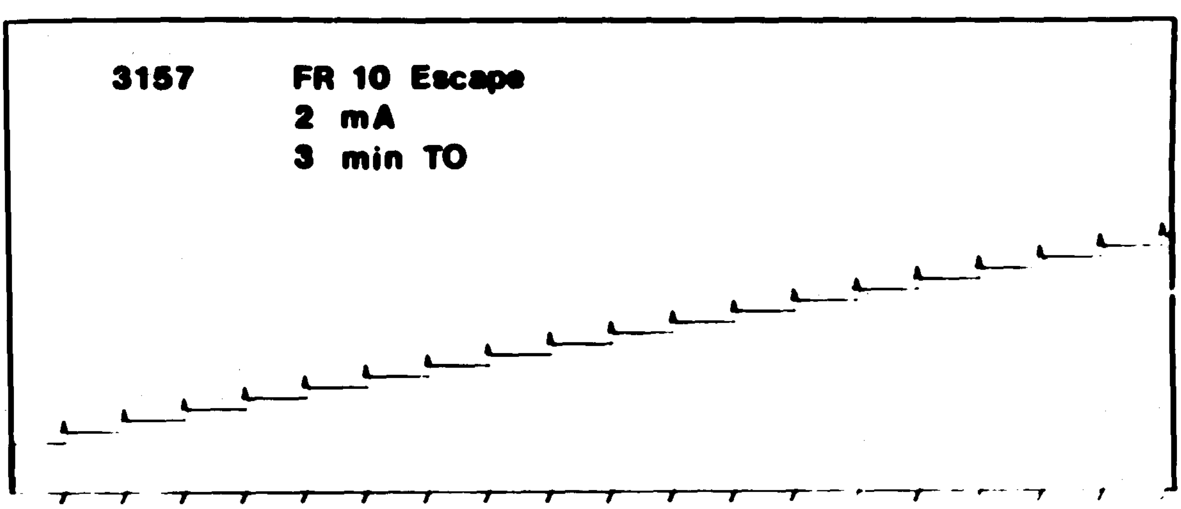


FIG. 1. Cumulative response record for Animal 3157 responding on an FR 10 schedule to escape the delivery of 2 mA of electric shock pulses. Ordinate: Cumulatives responses; Abscissa: Time. The event pen is deflected during the delivery of electric shock pulses. A deflection of the response pen indicates the completion of the FR 10 response requirement and the onset of the timeout period.

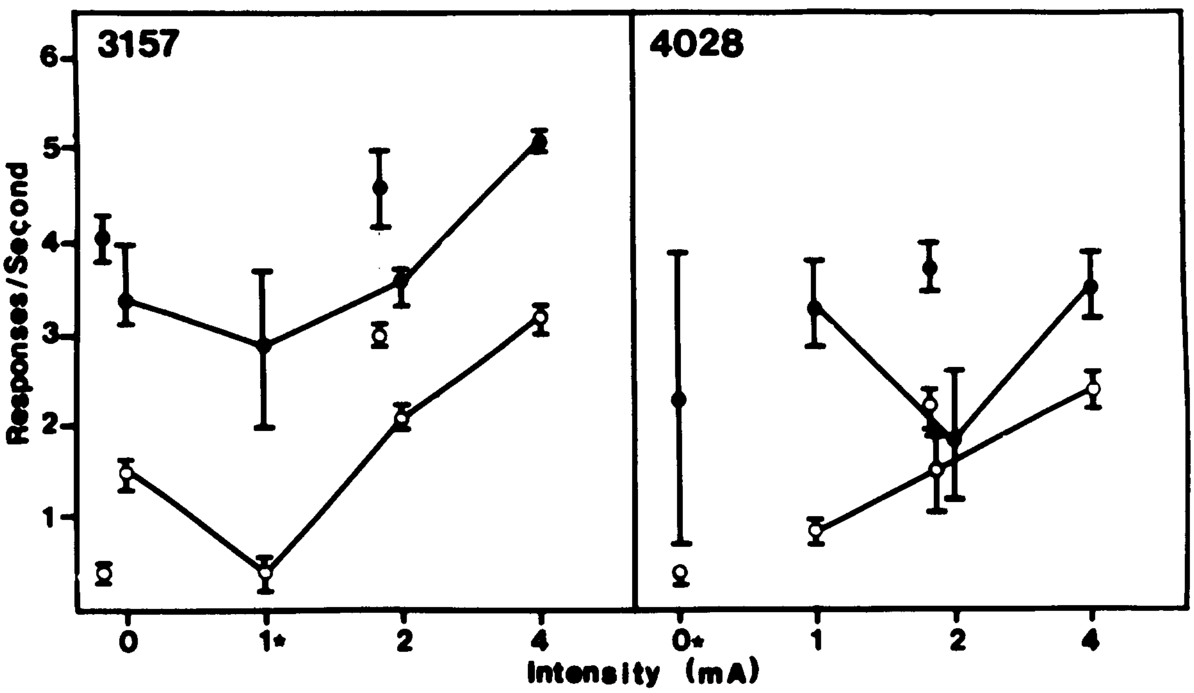


FIG. 2. Mean running response rates (•——•) and overall response rates (o——o) for Animals 3157 and 4028 as a function of the intensity of the shock. The means were calculated from the last three sessions at each intensity except for the conditions indicated by the asterisk (*). These data were calculated from only 2 sessions since no responding occurred on one of the last three sessions. The brackets indicate the range. Data from the redeterminations at 0 and 2 mA are shown to the left of the original. Original data are not shown for Animal 4028 at 0 mA since no responding occurred during any of the last three sessions.

increased from 1 to 4 mA, it did not decrease again when the intensity was decreased from 4 to 2 mA. On the other hand, Winograd [9] found that running response rate as well as overall response rate increased as intensity increased which was only partially true in the present study.

The major purpose of the present study was to develop an electric shock delivery system which could be used in situations where rhesus monkeys are restrained by a harness and arm arrangement often used in experiments where responding is maintained by delivery of intravenous drugs. The results indicate that the system does deliver an event which functions as a negative reinforcer capable of modifying responding. In addition, the system is easy to install, results in little or no tissue damage, is capable of being used with the experimental situation described and has functional characteristics which are stable over periods of time similar to intravenous catheters.

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